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ARTICLE

MULTISTAGE FEATURE EXTRACTION OF FINGER VEIN PATTERNS USING GABOR FILTERS

G Sankar Babu[1], N.D.Bobby[2], M Anto Bennet[3], B Shalini[4], K Srilakshmi[5]

[1]Asst.professor[2]Professor,[4,5]UG Students, Department of ECE,VEL TECH ,Avadi,Chennai 600 062, Tamil Nadu, INDIA

[3]Professor,Department of ECEVeltech High Tech Dr.Rangarajan Dr.Sakunthala Engg.College,Avadi,Chennai-600 062, Tamil Nadu, INDIA

ABSTRACT

This paper presents a new approach to improve the performance of finger-vein identification systems presented in the literature. The proposed system simultaneously acquires the finger-vein and low-resolution fingerprint images and combines these two evidences using a novel score-level combination strategy. We examine the previously proposed finger-vein identification approaches and develop a new approach that illustrates it superiority over prior published efforts. The utility of low-resolution fingerprint images acquired from a webcam is examined to ascertain the matching performance from such images. We develop and investigate two new score-level combinations, holistic and nonlinear fusion, and comparatively evaluate them with more popular score-level fusion approaches to ascertain their effectiveness in the proposed system.

KEY WORDS
Automated Fingerprint Identification Systems (AFIS), Region of Interest (ROI)

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***Corresponding Author**
Email:
bennetmab@gmail.com

INTRODUCTION

We propose a method of personal identification based on finger-vein patterns. An image of a finger captured under infrared light contains not only the vein pattern but also irregular shading produced by the various thicknesses of the finger bones and muscles. Radon transforms and neural networks are used for the identification of finger vein patterns [1-3]. The proposed method extracts the finger-vein pattern from the unclear image by using line tracking that starts from various positions. Experimental results show that it achieves robust pattern extraction, and the equal error rate was 0.145% in personal identification.In this work is on the development of new approaches for both the finger-vein and finger texture identification, which achieves significantly improved performance over previously proposed approaches the unconstrained finger texture imaging with a low-resolution webcam presents high rotational and translational variations [3-6]. A robust image normalization scheme is developed; rotational and translational variations are also accommodated in our matching strategy, which results in significantly improved performance. This paper investigates two new score-level combination approaches, holistic and nonlinear fusion, for combining finger-vein and finger texture matching scores.A Gabor filter is a linear filter whose impulse response is defined by a harmonic function multiplied by a Gaussian function. Because of the multiplication-convolution property (Convolution theorem), the Fourier transform of a Gabor filter's impulse response is the convolution of the Fourier transform of the harmonic function and the Fourier transform of the Gaussian function. Gabor filters are directly related to Gabor wavelets, since they can be designed for number of dilations and rotations. However, in general, expansion is not applied for Gabor wavelets, since this requires computation of biorthogonal wavelets, which may be very time-consuming. Therefore, usually, a filter bank consisting of Gabor filters with various scales and rotations is created [7,8].The Gabor Filters have received considerable attention because the characteristics of certain cells in the visual cortex of some mammals can be approximated by these filters. In addition these filters have been shown to posses optimal localization properties in both spatial and frequency domain and thus are well suited for texture segmentation problems. Gabor filters have been used in many applications, such as texture segmentation, target detection, fractal dimension management, document analysis, edge detection, retina identification, and image coding and image representation. A Gabor filter can be viewed as a sinusoidal plane of particular frequency and orientation, modulated by a Gaussian envelope.

G(x,y) = s(x,y) g(x,y) (1)

where s(x,y) is complex sinusoid and g(x,y) is 2D gaussian envelope

s(x,y) = exp . (2)

g(x,y) = exp (3)

and characterize the spatial extent and bandwidth of along the respective axes, and are the shifting frequency parameters in the frequency domain.

MATERIALS AND METHODS

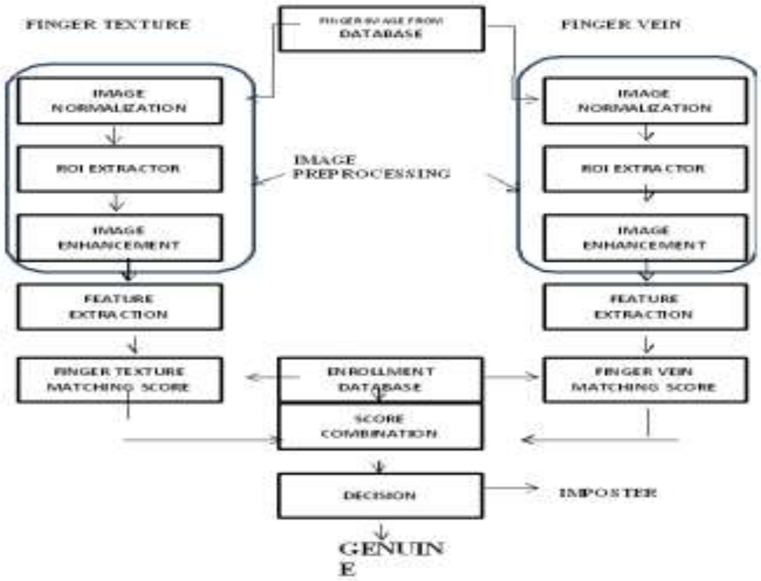

Fig.1: Block Diagram of finger vein & finger texture identification

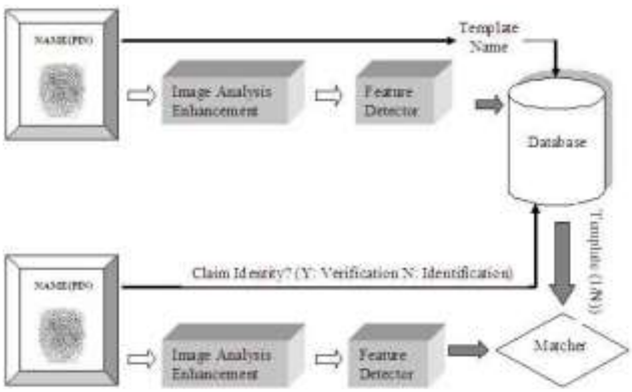

Fig. 2: Data Flow Diagram

Module 1: Finger Vein Identification

Image Normalization

Normalization is a process that changes the range of pixel intensity values. In this, the image is subjected to binarization with threshold value of 230. Sobel edge detector is applied to the image to the remove background portions connected to it. Eliminating the number of connected white pixels being less than a threshold, to obtain the binary mask. Binarization is a method of transforming grayscale image pixels into either black or white pixels by selecting a threshold. The process can be fulfilled using a multitude of techniques. Binarization is relatively easy to achieve compared with other image processing techniques.Finger print Image Binarization is to transform the 8-bit Gray fingerprint image to a 1-bit image with 0-value for ridges and 1-value for furrows. After the operation, ridges in the fingerprint are highlighted with black color while furrows are white. A locally adaptive binarization method is performed to binarize the fingerprint image shown in [Fig. 1].

ROI Extractor

In the finger images, there are many unwanted regions (that cannot be taken for analysis) has been removed by choosing the interested area in that image. The useful area is said to be "Region of Interest". The obtained binary mask is used to segment the ROI (Region of Interest) from the original finger-vein image. The orientation of the image is determined to remove the low quality images that present in finger vein image. This orientation is used for the rotational alignment of the ROI in vein image.

Fingerprint Image Segmentation

In general, only a Region of Interest (ROI) is useful to be recognized for each fingerprint image. The image area without effective ridges and furrows is first discarded since it only holds background information. Then the bound of the remaining effective area is sketched out since the minutia in the bound region is confusing with that spurious minutia that is generated when the ridges are out of the sensor. To extract the ROI, a two-step method is used. The first step is block direction estimation and direction variety check, while the second is intrigued from some Morphological methods.

Block direction estimation

The direction for each block of the fingerprint image with W x W in size(W is 16 pixels by default)is estimated. The algorithm is:

I.The gradient values along x-direction (gx) and y-direction (gy) for each pixel of the block is calculated. Two Sobel filters are used to fulfill the task.

II. For each block, following formula is used to get the Least Square approximation of the block direction.

$$tg2\beta = 2 \Sigma \Sigma (g_x * g_y) / \Sigma \Sigma (g_x^2 - g_y^2) \quad (7)$$

The formula is easy to understand by regarding gradient values along x-direction and y-direction as cosine value and sine value. So the tangent value of the block direction is estimated nearly the same as the way illustrated by the following formula.

$$tg2\theta = 2\sin\theta \cos\theta / (\cos^2\theta - \sin^2\theta) \quad (8)$$

After the estimation of each block direction, those blocks without significant information on ridges and furrows are discarded based on the following formulas:

$$E = \{2 \Sigma \Sigma (g_x * g_y) + \Sigma \Sigma (g_x^2 - g_y^2)\} / W * W * \Sigma \Sigma (g_x^2 + g_y^2) \quad (9)$$

For each block, if its certainty level E is below a threshold, then the block is regarded as a background block.

ROI extraction by Morphological operations

Two Morphological operations called 'OPEN' and 'CLOSE' are adopted. The 'OPEN' operation can expand images and remove peaks introduced by background noise. The 'CLOSE' operation can shrink images and eliminate small cavities. The bound is the subtraction of the closed area from the opened area. Then the algorithm throws away those leftmost, rightmost, uppermost and bottommost blocks out of the bound so as to get the tightly bounded region just containing the bound and inner area.

Image Enhancement

The acquired image is thin and it is not clear. So the image is enhanced by using bicubic interpolation for better visualization. Fingerprint Image enhancement is to make the image clearer for easy further operations. Since the fingerprint images acquired from sensors or other Medias are not assured with perfect quality, those enhancement methods, for increasing thecontrast between ridges and furrows and for connectingthe falsebroken points of ridges due to insufficient amount of ink, are very useful for keep a higher accuracy to fingerprint recognition. The Method adopted in fingerprint recognition system is Histogram Equalization. Histogram equalization is to expand the pixel value distribution of an image so as to increase the perceptional information. The original histogram of a fingerprint image has the bimodal type. The histogram after the histogram equalization occupies all the range from 0 to 255 and the visualization effect is enhanced.

Module 2: Finger Texture Identification

Localization and Normalization

In texture preprocessing, Sobel edge detector is used to obtain the edge map and localize the finger boundaries. This edge map is isolated with noise and it can be removed from the area threshold. Such noise is eliminated from the area thresholding, i.e., if the number of consecutive connected pixels is less than the threshold. The slope of the upper finger boundary is then estimated. This slope is used to automatically localize a fixed rectangular area, which begins at a distance of 20 pixels from the upper

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finger boundary and is aligned along its estimated slope. We extract a fixed 400 160 pixel area, at a distance of 85 and 50 pixels, respectively, from the lower and right boundaries, from this rectangular region. This 400 160 pixel image is then used as the finger texture image for the identification.

Image Enhancement

In Image enhancement, finger texture image is subjected to median filtering to eliminate the impulsive noise. The resulting images have low contrast and uneven illumination. Therefore obtain the background illumination image from the average of pixels in 10 10 pixel image subblocks and bicubic interpolation.The resulting image is subtracted from the median-filtered finger texture image and then subjected to histogram equalization.

Finger Vein and Texture Image Feature Extraction

Gabor filter is used for finger vein and texture image feature extraction. Gabor filters optimally capture both local orientation and frequency information from a fingerprint image. Bytuning a Gabor filter to specific frequency and direction, the local frequency and orientation information can beobtained. We have creating the Gabor with specified orientations and these Gabor filter is convolved with the enhanced image to remove the unwanted regions other than the vein and texture regions. In vein images, the extracted vein images are further processed into morphological top-hat operation for obtaining the clear vein patterns shown in [Fig. 2].

Module 3: Finger Texture Identification

Finger Vein and Texture Matching

In that, the matcher block predicts that the vein and texture image is matched with the database. The database contains the features of all vein and texture images.
For matching, two steps has been done

- Extract features
- Match features

These two steps are done by using Matlab in built commands. Vein regions extracted from the image are stored in database.

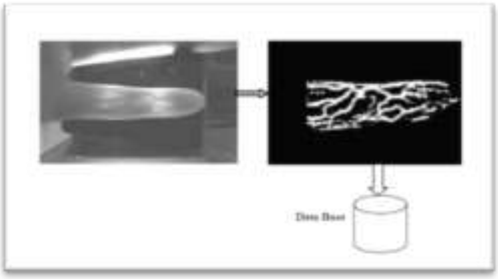

Fig. 3: Data base

Vein Matching

The features extracted from finger vein images are already stored in a database. The features of the input image are matched with all the extracted veins in the database to check whether the input image is matched with any one of the extracted veins.

- If the input image is matched with any one of the extracted veins, the message box will be opened and display “vein matched”.
- If the input image is not matched with any one of the extracted veins, the message box will be opened and display “vein not matched”.

Texture Matching

The features extracted from finger texture images are stored in the same database. The features of the input image are matched with all the extracted texture in the database to check whether the input image is matched with any one of the extracted textures.

- If the input image is matched with any one of the extracted textures, the message box will be opened and display “texture matched”.

- If the input image is not matched with any one of the extracted textures, the message box will be opened and display “texture not matched”.

Module 4: Score Combination

In score level combination, two techniques are used.

- Holistic fusion
- Nonlinear fusion

These two techniques are used to combine the resultant finger vein and texture images. The result of this fusion is used to check whether the fingerprint is genuine or not.

Holistic Fusion

This approach is developed and investigated to utilize the prior knowledge in the dynamic combination of matching scores. Let , and represent the matching score from finger vein, finger texture, and combined score, respectively, and this holistic rule of score combination is given below: (10)The above equation can also be written as,(11).

By using this equation, the final combined scores have a similar trend as the score from vein matching, i.e., when the score from finger-vein matching is high, the fused score will also become high and vice versa. Factor is selected to reflect the reliability of each modality or matching score. We choose the matching score from finger vein as the controlling factor since the performance of finger-vein matching is more stable, as compared with that of the texture.

Nonlinear Fusion

This nonlinear score combination attempts to dynamically adjust the combined score according to the degrees of consistency between the two matching scores and is illustrated as below: (12)

Where is a positive constant and is fixed to 1 in our experiments and is selected in the range of [1,2].

RESULTS

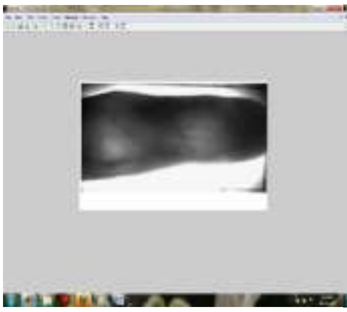

Fig. 4: Original image **Fig. 5:** Binarised image

Fig. 6: Freehand selection for ROI Extraction **Fig. 7:** ROI


Fig. 8: Enhanced image **Fig. 9:** Feature Extracted Vein


Fig. 9: Vein match **Fig.10:**Texture input image

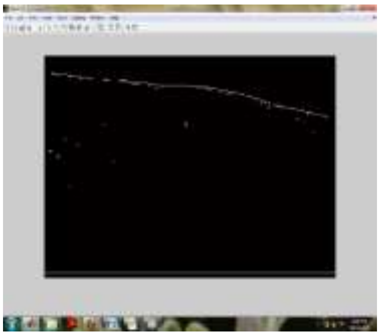
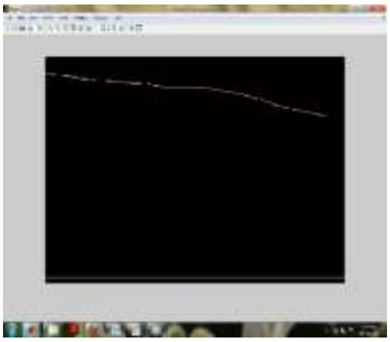

Fig. 11: Edge detection using sobel **Fig. 12:** Image after area thresholding


Fig. 13: Segmented image **Fig. 14:** Image median filtered image

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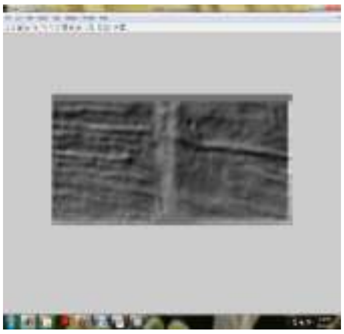

Fig. 15: Enhanced Texture image **Fig. 16:** Feature Extracted image

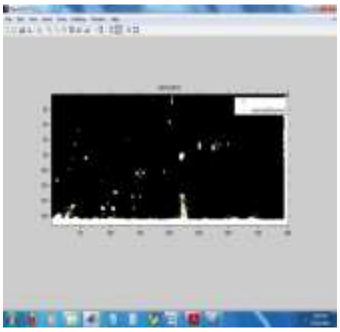

Fig. 17: Texture Match **Fig.18:** Matching Scores

In this study ground glass pattern detection of HRCT images is done for better visualization and their analysis. For this we have taken the HRCT images of lungs from Ground glass opacity patients. These are basically RGB images and these are converted to GRAY SCALE images for making further process easy. Then preliminary mask is obtained using Gabor high pass and Gabor low pass filters. Thresholding and Morphological operations such as erosion and dilation are performed to obtain peripheral mask. This peripheral mask contains noise which appears as tiny dots and they are often few pixels wide. For getting accuracy, we are going for post processing technique in which the noise is removed by median filters. This may assist doctors for making decisions for better and quick treatment. The results obtained from the above steps are shown in the following [Fig. 4–18]

CONCLUSION

We have presented a complete and fully automated finger image matching framework by simultaneously utilizing the finger surface and finger subsurface features. We presented a new algorithm for the finger-vein identification, which can more reliably extract the finger vein shape features and achieve much higher accuracy than previously proposed finger-vein identification approaches. Our finger-vein matching scheme works more effectively in more realistic scenarios and leads to a more accurate performance, as demonstrated from the experimental results.In proposed and investigated two new score-level combination approaches, i.e., nonlinear and holistic, for effectively combining simultaneously generated finger-vein and finger texture matching scores. The nonlinear approach consistently performed better than other promising approaches, average, product, weighted sum, Dempster–Shafer, and likelihood-ratio approaches. We examined a complete and fully automated approach for the identification of low resolution finger surface texture images for the performance improvement. This investigation and they obtained results are significant as they point toward the utility of touch less images acquired from the webcam for personal identification and its extension for other utilities such as mobile phones, surveillance cameras, and laptops. Finally, the availability of the acquired database from this paper for the benchmarking/comparison will help further the research efforts in this area. Currently, there is no publicly available database for the performance comparison and research efforts on finger-vein identification.

CONFLICT OF INTEREST

There is no conflict of interest.

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FINANCIAL DISCLOSURE

None.

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